IBO IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

BIOLOGY
STANDARD LEVEL
PAPER 3

Candidate number

Monday 17 November 2003 (morning)

1 hour

INSTRUCTIONS TO CANDIDATES

- Write your candidate number in the box above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options in the spaces provided. You may continue your answers on answer sheets. Write your candidate number on each answer sheet, and attach them to this examination paper using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.

Option A – Diet and Human Nutrition

A1. Retinol (vitamin A) deficiency is a major nutritional problem in India. Normally a good source of retinol in the diet is β–carotene in green, leafy vegetables, which the body converts into active retinol. Food scientists wanted to see if drying leaves of two species of crop plant would retain their nutritional value. Savoy beets (*Beta vulgaris*) and fenugreek (*Trigonella foenum graecum*) were treated in a low temperature drier and stored for nine months at room temperature or 8 °C (cold storage). The leaves were packed in one plastic bag (single packed) or in two plastic bags, one inside the other, (double packed). The results are shown in the table below.

	β–carotene / mg per 100 g of leaves							
Plant	Savoy beet				Fenugreek			
Storage	Single packed		Double packed		Single packed		Double packed	
Temperature	Room	Cold	Room	Cold	Room	Cold	Room	Cold
Start	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
After 3 months	28.4	30.9	33.7	32.8	27.9	28.5	28.7	29.4
After 6 months	23.4	25.3	28.0	30.1	19.4	24.5	23.4	26.0
After 9 months	18.3	18.2	17.9	21.1	8.9	21.1	12.3	23.2

[Source: S Negi and S K Roy (2001), *Plant Foods for Human Nutrition*, **56**, pages 285–295]

(a) Calculate the percentage loss of β–carotene from the Savoy beets after nine months when they are

   (i)   single packed and cold stored   . . . .

   (ii)   double packed and cold stored.   . . . .   *[2]*

(b) Outline **one** function of retinol.   *[1]*

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(c) Compare the effect of storage after six months at room temperature on the β–carotene levels   *[2]*
   in the Savoy beet with fenugreek.

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(This question continues on the following page)

(Question A1 continued)

(d)   Evaluate the effects of double packing these leaf tissues. *[2]*

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(e)   Suggest why there is a difference between single packing and double packing of the dried leaves. *[1]*

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A2.   (a)   List the groups of macromolecules which provide energy in the diet. *[2]*

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(b)   Discuss the variation in energy requirements as a child grows to maturity. *[4]*

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Turn over

A3. (a) Define the term *nutrient*. *[1]*

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(b) Discuss the relationship between nutrition and rickets. *[3]*

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Option B – Physiology of Exercise

B1. Physiologists measured the amount of glycogen stored in the muscle tissues of six athletes during a training period. The athletes ran 16 km each day for three consecutive days. The glycogen levels were measured before (pre-) and after (post-) each run. The athletes were allowed to rest for five days and the muscle glycogen levels were measured again. The data are shown in the scattergram below. Each athlete is shown by a different symbol (*e.g.* □ is athlete A).
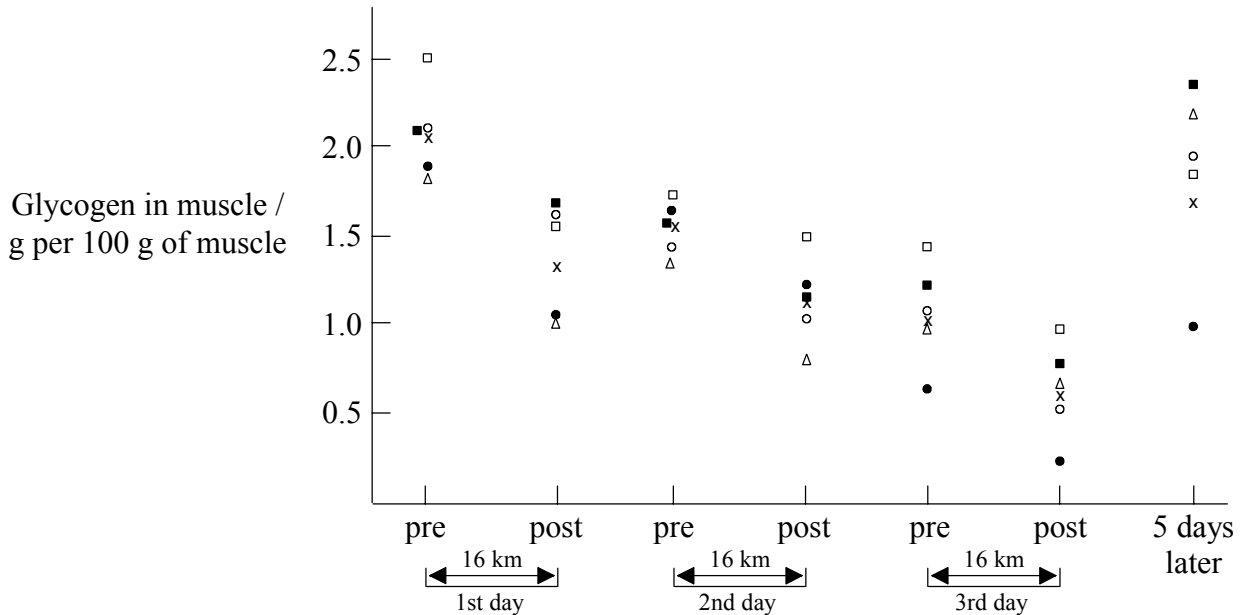
[Source: W D McArdle, *et al.* (1987), *Physiologie de l'activité Physique. Energie, Nutrition et Performance.*, *Vigot*, pages 51–52]

(a) State the effect of running on the muscle glycogen levels.   *[1]*

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(b) Describe the effect of the training programme on the levels of muscle glycogen.   *[2]*

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Glycogen is a stored form of carbohydrate. For each athlete approximately 50 % of their diet was carbohydrate.

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(c) Outline the importance of carbohydrate supplies in muscle tissue during running.

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(This question continues on the following page)

(Question B1 continued)

    (d)   Discuss the implications of this information for long distance runners training for a sports event. *[3]*

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B2. (a) Identify the structures labelled I and II on the diagram of the elbow joint below. *[2]*

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II. . . . .
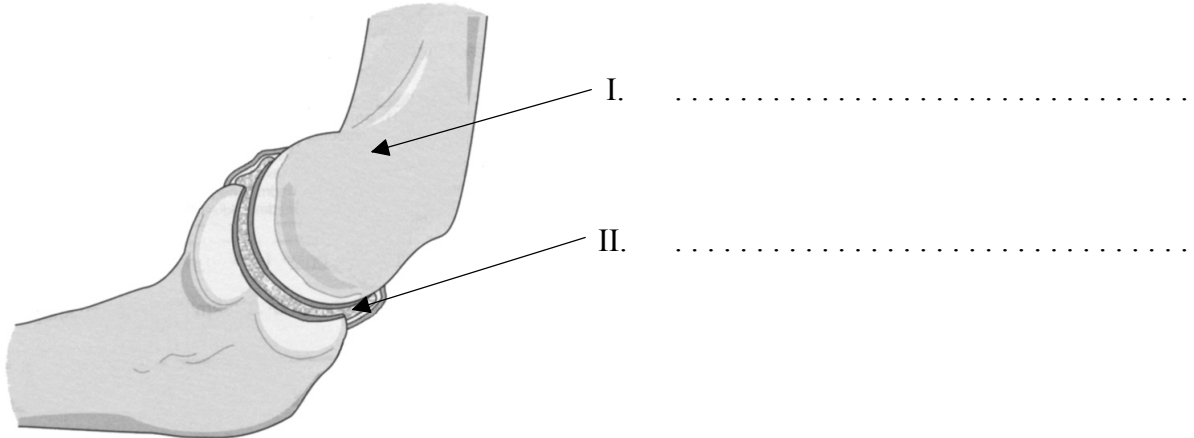
[Source: R Allen and T Greenwood, (2001) *Advanced Biology 2, Student Resource and Activity Manual,* 3rd edition, Biozone International Limited, page 98]

(b) Explain how the action of the muscles is co-ordinated at this joint by the nervous system. *[3]*

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(c) State and describe **one** injury that could occur in this joint. *[2]*

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B3. Explain the changes in ventilation with exercise. *[3]*

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Option C – Cells and Energy

C1. The unicellular green alga *Phaeodactylum tricornutum* is photosynthetic. Cell biologists genetically modified this organism by adding a glucose transporter gene. The modified and unmodified algae were grown in a nutrient medium under a series of different conditions and the growth rate of the cells was measured.

Key:
● = light and no glucose in the medium
○ = light and glucose in the medium
▼ = dark and glucose in the medium
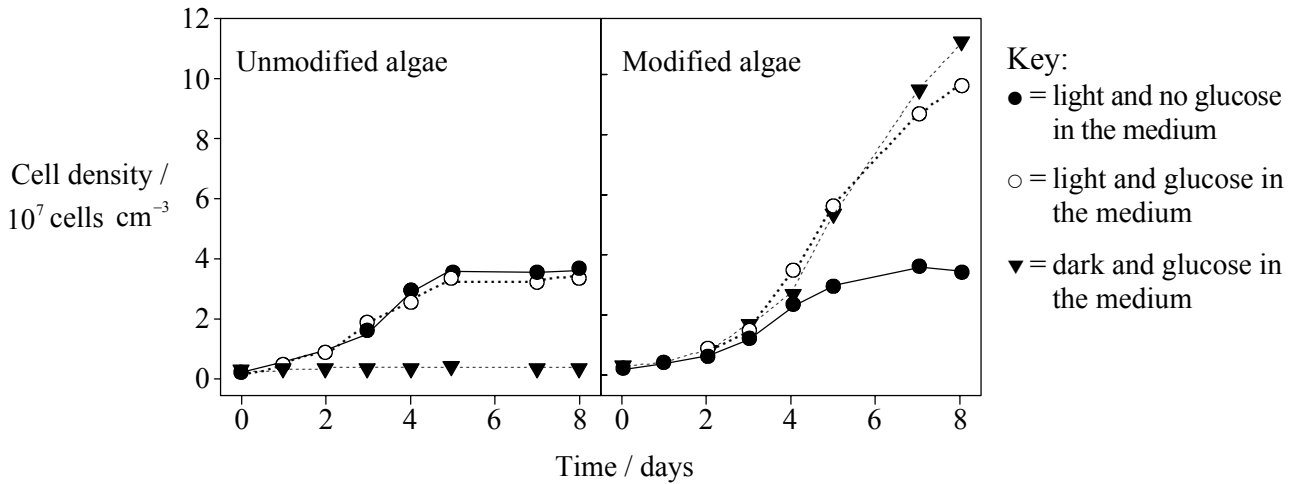
[Source: L A Zaslavskaia, *et al.*, adapted (2001) *Science*, **292**, pages 2073–2075]

(a)   State the role of glucose in the metabolism of cells.   *[1]*

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(b)   Deduce where you would expect to find the glucose transporter protein in the modified algae cells.   *[2]*

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(c)   Compare the effect of light on the modified and the unmodified cells.   *[2]*

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(This question continues on the following page)

(Question C1 continued)

Commercially, unmodified algae are grown in shallow sunlit ponds or illuminated containers. The cells only grow in the top few centimetres. However, the modified algae can grow at any depth.

(d)   Explain why the modified algae can grow at any depth whereas the unmodified algae can only grow at the surface. *[3]*

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C2. (a)   State **one** named example of a fibrous protein and **one** named example of a globular protein. *[2]*

Fibrous: . . . .   Globular: . . . .

(b)   Outline the effect of enzymes on the reactions they catalyse. *[2]*

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(c)   The rate of cellular respiration is controlled by the allosteric inhibition of phosphofructokinase by ATP. Phosphofructokinase is the first enzyme in the respiration pathway. Explain the meaning of allosteric inhibition using this example. *[4]*

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C3. State **two** products of the light dependent reaction of photosynthesis. *[2]*

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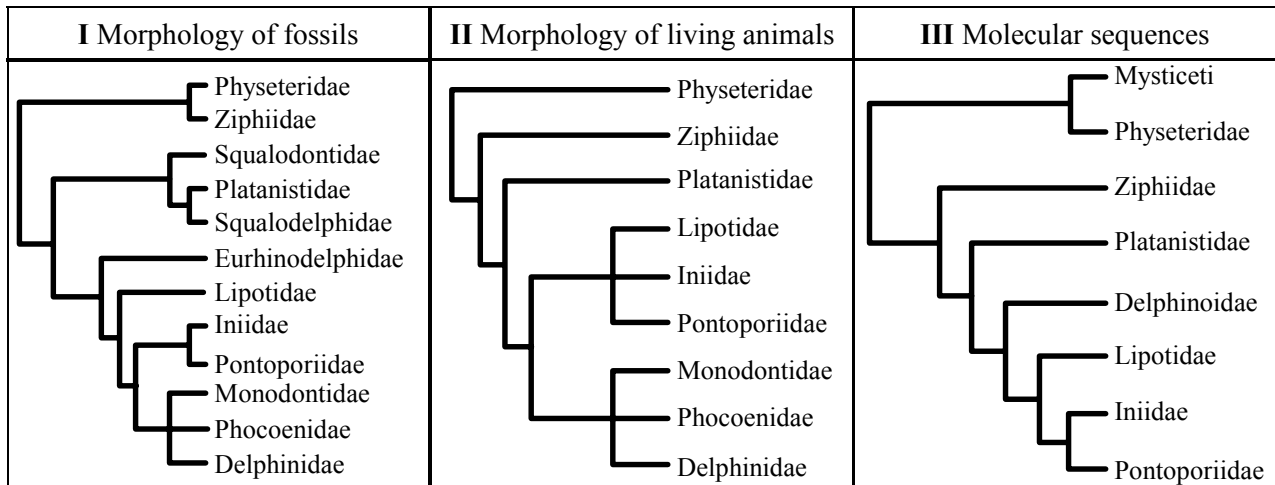
Option D – Evolution

D1. River dolphins live in freshwater habitats or estuaries. They have a number of features in common which distinguish them from other dolphins: long beaks, flexible necks, very good echo-location and very poor eyesight. Only four families of river dolphin have been found in rivers around the world.

River	River Dolphin Family
Amazon, Brazil	Iniidae
La Plata, Argentina	Pontoporiidae
The Yangtze, China	Lipotidae
The Indus and Ganges, India	Platanistidae

Evolutionary biologists have tried to determine how closely related these river dolphins are to one another. River dolphins are members of the group the toothed whales. Three lines of evidence were analysed producing three cladograms (family trees) for all the toothed whales. The evidence to construct these cladograms came from the morphology (form and structure) of fossil toothed whales (**I**), the morphology of living toothed whales (**II**) and the molecular sequences from living toothed whales (**III**)

I Morphology of fossils	II Morphology of living animals	III Molecular sequences
Physeteridae	Physeteridae	Mysticeti
Ziphiidae	Ziphiidae	Physeteridae
Squalodontidae	Platanistidae	Ziphiidae
Platanistidae	Lipotidae	Platanistidae
Squalodelphidae	Iniidae	Delphinoidae
Eurhinodelphidae	Pontoporiidae	Lipotidae
Lipotidae	Monodontidae	Iniidae
Iniidae	Phocoenidae	Pontoporiidae
Pontoporiidae	Delphinidae	
Monodontidae		
Phocoenidae		
Delphinidae		

[Source: H Hamilton, *et al.*, (2001) *Proc R Soc Lond B*, **268**, pages 549–556]

(a) Suggest a reason why there are more families present in cladogram I, produced from the morphology of fossils, than for the other cladograms. *[1]*

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(b) Using only the data from cladogram III, identify which other family of river dolphins is most closely related to Platanistidae. *[1]*

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(This question continues on the following page)

(Question D1 continued)

(c) State what material would be used to produce cladogram III, based on the molecular sequences of living toothed whales. *[1]*

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The tree using the data from the morphology of living animals (II) indicates that the families are more closely related than the tree using molecular sequences (III) from the same animals.

(d) Explain how these dolphins can look so similar when in fact they may not be so closely related. *[3]*

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These cladograms show the species that share common ancestors but do not show how long ago they diverged from one another.

(e) Outline further evidence that would be needed to determine when these families of toothed whales diverged. *[2]*

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D2. (a) Outline the trends illustrated by the fossils of *Australopithecus afarensis*.   *[3]*

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(b) Discuss the origin and consequences of bipedalism in hominids.   *[4]*

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D3. State **three** conditions thought to have been present on the pre-biotic Earth.   *[3]*

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Option E – Neurobiology and Behaviour

E1. Entomologists investigating communication between worker bees (*Apis melifera*) observed workers collecting sugar solutions from feeder stations placed at different distances from the hive. The workers' waggle dances were filmed as they returned to the hive and the duration of the waggle was measured. The results are shown in the graph below.
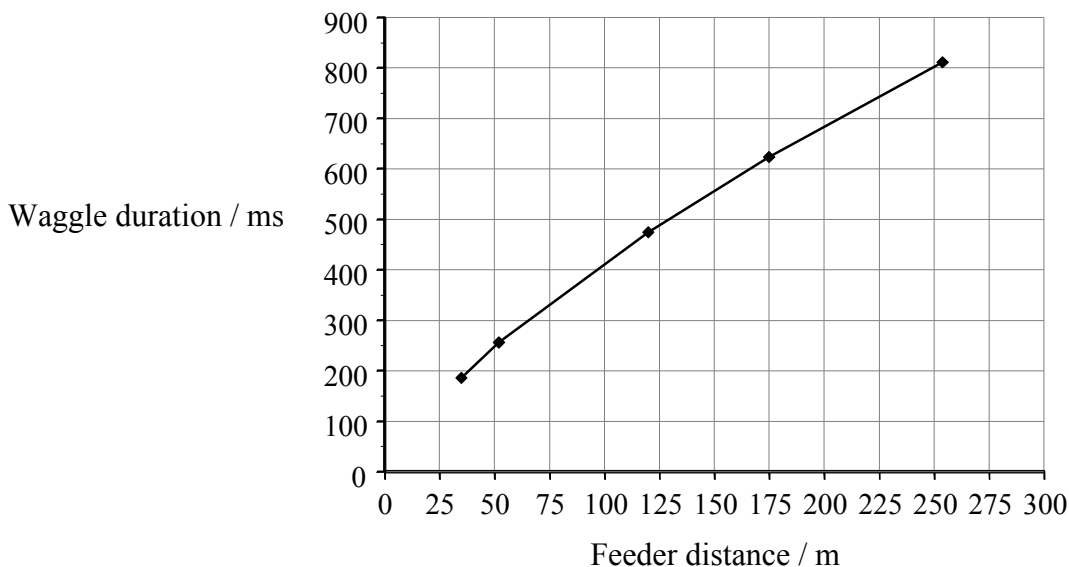
[Source: H E Esch, *et al.* (2001), *Nature*, **411**, pages 581–583]

(a) State the relationship between the duration of the waggle dance and the distance from the feeder hive. *[1]*

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(b) State another piece of information that worker bees communicate to one another. *[1]*

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Worker bees were then trained to collect sugar solution by flying down an 8 m long tunnel running south from the hive. The tunnel was placed so that the entrance was 3 m from the hive. The floor and walls of the tunnel were covered with a black and white chequered pattern but the roof was covered in netting so the bees could see the sky.

(c) Calculate the actual distance of the sugar solution at the end of the tunnel from the hive. *[1]*

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(This question continues on the following page)

(Question E1 continued)

When the bees returned to the hive, the duration of their waggle was recorded and found to have a mean of 350 ms.

(d)   Using the graph opposite, determine the distance to the sugar solution indicated by the duration of the waggle dance by the worker bees returning from the tunnel.   *[1]*

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(e)   Deduce why there is a difference between the real distance flown by the bees and the information that they passed on to their fellow workers in the hive.   *[2]*

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(f)   Suggest a modification to the experiment that would help to test your answer to (e).   *[1]*

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E2. (a)   Distinguish between innate and learned behaviour.   *[2]*

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(b)   Explain, using a named example, the behaviour of migration.   *[4]*

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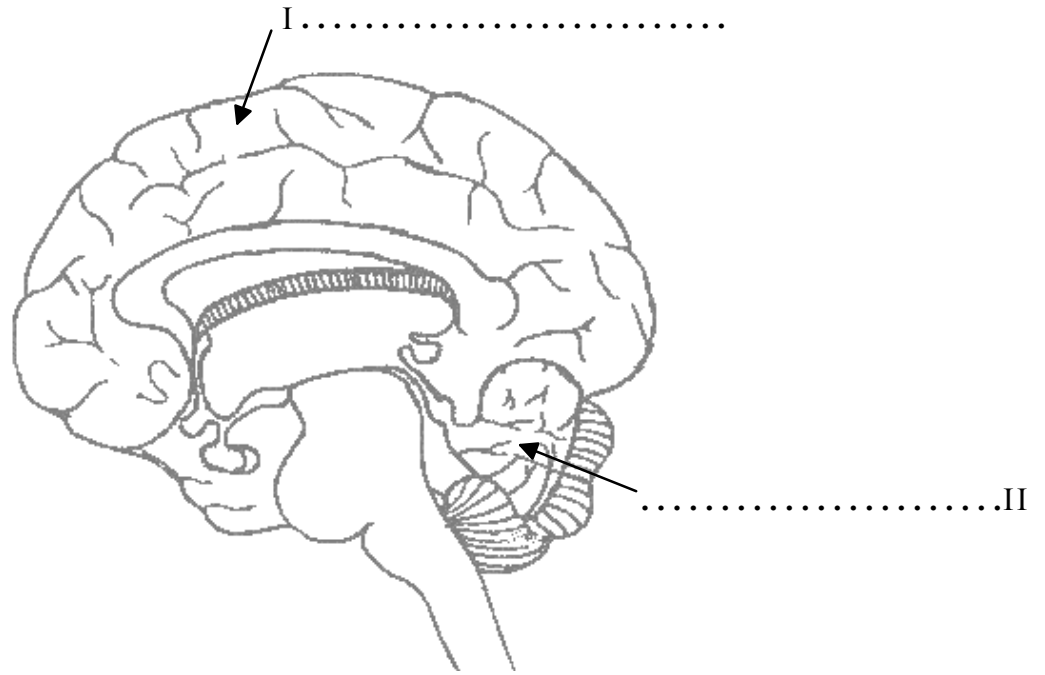
I . . . .

. II

(a)   Identify the parts labelled I and II on the diagram of the brain shown above.   *[2]*

(b)   Outline the use of the pupil reflex as part of the test for brain death.   *[2]*

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(c)   State **two** types of human sensory receptors.   *[1]*

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Option F – Applied Plant and Animal Science

F1. Entomologists studied two species of insect pest, the cabbage root fly (*Delia radicum*) and the peach-potato aphid (*Myzus persicae*). Both of these insects are pests on the cauliflower plant (*Brassica oleracea*). They wanted to see if the presence of one pest on a plant would repel another pest species.

When it is disturbed, the peach-potato aphid produces an alarm pheromone, a chemical signal that disperses in the air. Five sets of 15 cauliflower plants were each sprayed with different levels of the aphid's pheromone dissolved in ethylan. Another five sets of cauliflowers were treated with distilled water and ethylan. (Ethylan helps to spread the pheromone over the surface of the plants.)

Mature cabbage root fly females were released into the cages where the treated cauliflower plants were growing. They were left for one day and the number of eggs laid by the female root flies were counted. The data is shown in the bar chart below.
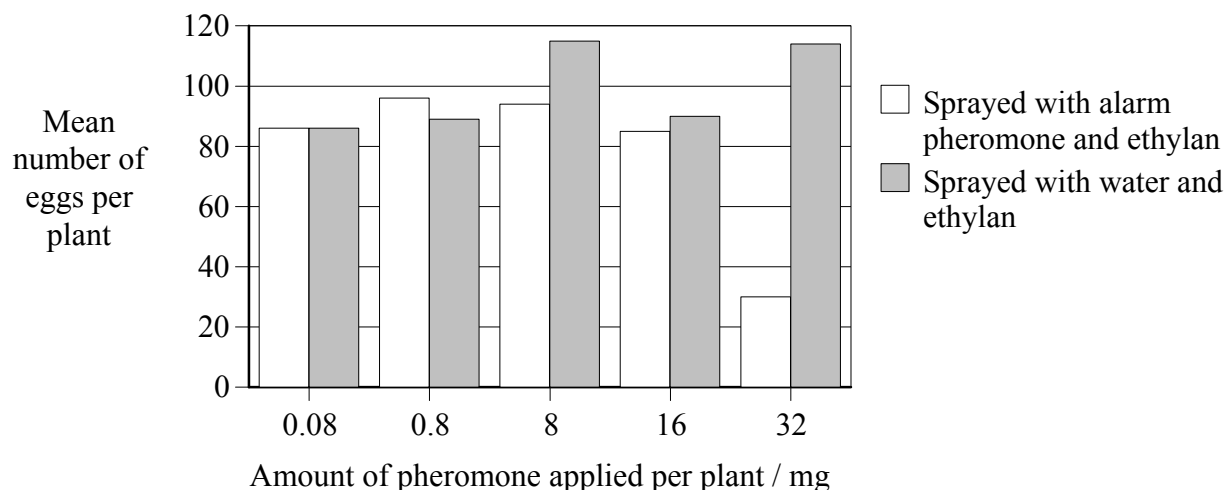
[Source: S Finch and T S Jones (1989), *Ecological Entomology*, **14**, pages 387–391]

(a) Compare the results of treatments with and without the pheromone. *[2]*

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(b) Suggest a reason why aphids produce an alarm pheromone. *[1]*

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(This question continues on the following page)

(Question F1 continued)

Each aphid can release about 1 ng of pheromone (1 ng $= 10^{-9}$ g).

(c) Calculate how many aphids must simultaneously release pheromone to produce 32 mg. *[1]*

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(d) Discuss the possible use of peach-potato aphids to control the cabbage root fly pest. *[3]*

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F2. (a) Distinguish between plant growth regulators and fertilizers. *[2]*

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(b) Explain the techniques used in cloning by micropropagation of plants. *[3]*

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(c) Outline the effects of pruning on plants *[2]*

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F3. (a) Define *outbreeding*.   *[1]*

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   (b) Discuss the importance to farmers of maintaining biodiversity of **either** wild plants **or** ancient farm breeds.   *[3]*

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Option G – Ecology and Conservation

G1. Basking sharks (*Cetorhinus maximus*) filter feed on zooplankton (small floating marine animals) in temperate coastal seas. Marine biologists recorded the swimming paths taken by two basking sharks about 8 km off the coast of Plymouth (UK). At the same time the densities of zooplankton (in $g\,m^{-3}$) were recorded within 3 m of the swimming path of the sharks.
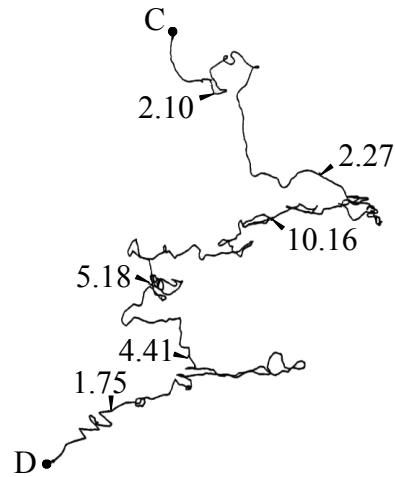
[Source: D W Sims and V A Quayle (1998), *Nature*, **393**, pages 460–464]

(a) Using the scale given, calculate the straight line distance,

    (i) from point A to point B.

    . . . .
    . . . .

    (ii) from point C to point D.   *[2]*

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    . . . .

(b) Outline the difference in the swimming behaviour between shark 1 and shark 2.

                                                                                                     [1]

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(This question continues on the following page)

(Question G1 continued)

(c) Using the data given, suggest reasons for the difference in the swimming behaviour of the two sharks. *[3]*

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(d) State **two** factors other than food which may affect the distribution of the basking sharks. *[2]*

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G2. (a) Outline the effect of living organisms on soil conditions. *[2]*

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(b) Discuss the economic reasons for the conservation of tropical rainforest biodiversity. *[3]*

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G3. (a) Simpson's index is given by the following equation:

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

where:
D = the diversity index, *N* = the total number of all species found and *n* = the number of individuals of a particular species.

(i) State what would happen to this index if the numbers of one species increased but the total number of species stays the same. *[1]*

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(ii) State what a high value of D suggests about an ecosystem. *[1]*

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(b) Explain the use of biotic indices in monitoring environmental changes. *[3]*

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